

# **MAPPING DATA ACQUISITION AND PROCESSING SUMMARY REPORT:**

## **EX-15-04 Leg 3, Hohonu Moana 2015: Exploring the Deep Waters off Hawai'i (ROV & Mapping)**

**Report Author: Derek C. Sowers<sup>1</sup>**

**Contributors: Kelley Elliott<sup>2</sup>, Chris Kelley<sup>3</sup>, Frank Parrish<sup>4</sup>, Joy Nalley<sup>5</sup>, Annie Raymond<sup>6</sup>**

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<sup>1</sup> Cherokee Nation Strategic Programs, at NOAA Ocean Exploration and Research

<sup>2</sup> NOAA Ocean Exploration and Research

<sup>3</sup> University of Hawai'i at Manoa

<sup>4</sup> NOAA Pacific Islands Fisheries Science Center

<sup>5</sup> NOAA Office of Marine and Aviation Operations

<sup>6</sup> NOAA Pacific Hydrographic Branch

## 1. Introduction

The NOAA Office of Ocean Exploration and Research is the only federal program dedicated to exploring our deep ocean, closing the prominent gap in our basic understanding of U.S. deep waters and seafloor and delivering the ocean information needed to strengthen the economy, health, and security of our nation.

Using the latest tools and technology, OER **explores** previously unknown areas of our deep ocean, making discoveries of scientific, economic, and cultural value. Through live video streams, online coverage, training opportunities, and real-time events, OER allows scientists, resource managers, students, members of the general public, and others to actively **experience** ocean exploration, expanding available expertise, cultivating the next generation of ocean explorers, and engaging the public in exploration activities. From this exploration, OER makes the collected data needed to **understand** our ocean publicly available, so we can maintain the health of our ocean, sustainably manage our marine resources, accelerate our national economy, and build a better appreciation of the value and importance of the ocean in our everyday lives.



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## 2. Report Purpose

The purpose of this report is to briefly describe the acoustic seafloor and water column mapping data collection and processing methods used during exploration expedition EX-15-04 L3, and to present a summary of the overall mapping results and mapping related cruise activities. A detailed description of the *Okeanos Explorer's* mapping capabilities is available in the 2015 NOAA Ship *Okeanos Explorer* Survey Readiness Report, available in the NOAA Central Library. A full description of Remotely Operated Vehicle (ROV) operations and sample collections completed during the cruise is available in a separate Expedition Report available in the NOAA Central Library with the title "*Cruise Report: EX-15-04 L3, Hohonu Moana 2015: Exploring the Deep Waters off Hawai'i (ROV & Mapping).*"

## 3. Cruise Objectives

EX-15-04 L3 was one of a series of NOAA Ship *Okeanos Explorer* expeditions from 2015 to 2017 planned to contribute to NOAA's multi-year Campaign to Address Pacific monument Science, Technology, and Ocean NEeds (CAPSTONE). NOAA priorities for the CAPSTONE campaign included a combination of science, education, outreach, and open data objectives that will support management decisions at multiple levels. CAPSTONE was a 3-year effort designed to provide critical new information on the deep water resources within the U.S. marine national monuments and sanctuaries located throughout the Pacific. The primary goal of all *Okeanos Explorer* expeditions in this campaign was to obtain baseline characterizations of the very poorly known deep water areas and resources in these extensive marine protected areas.

EX-15-04 L3 operations focused on NOAA Pacific Islands Fisheries Science Center (PIFSC) instrument recovery around the Main Hawaiian Islands, a dive in support of a coral disturbance/recovery study on substrate formed by lava flows off South Point of the Big Island, and several dives at the Geologists Seamounts in support of National Marine Fisheries Service Pacific Islands deep-sea coral priorities. The primary goal for this expedition was to recover instruments, fill in some data gaps to wrap up prior work, and collect baseline data to support priority NOAA science and management needs. The primary mapping objective for EX-15-04 L3 in the Main Hawaiian Islands was to obtain EM 302 multibeam sonar backscatter data on Ellis and McCall seamounts in the Geologists Seamounts group, which lacked existing sonar backscatter information. A complete list of cruise objectives is available in the Project Instructions document for the cruise available at <http://doi.org/10.7289/V5DB7ZVQ>.

The EX-15-04 L3 expedition was a 7-day expedition that started on August 28, 2015 and ended on September 3, 2015. The cruise started and ended in port facilities in Pearl Harbor in Honolulu, HI. The expedition included 24-hour per day operations, with daytime ROV dives supported with shore-side participation via telepresence technology and overnight mapping operations.

## 4. Summary of Mapping Results

Multibeam mapping operations covered an area of 6,400 square kilometers of seafloor over a linear ship track distance of 1,204 kilometers. All of this seafloor area was within the U.S. exclusive economic zone (EEZ) deeper than 200 m. Multibeam bathymetry data coverage and ROV dive locations are shown in Figure 1.

### Cruise Overview Map

#### Hohonu Moana 2015: Exploring the Deep Waters off Hawai'i Multibeam Bathymetry and ROV Dive Map

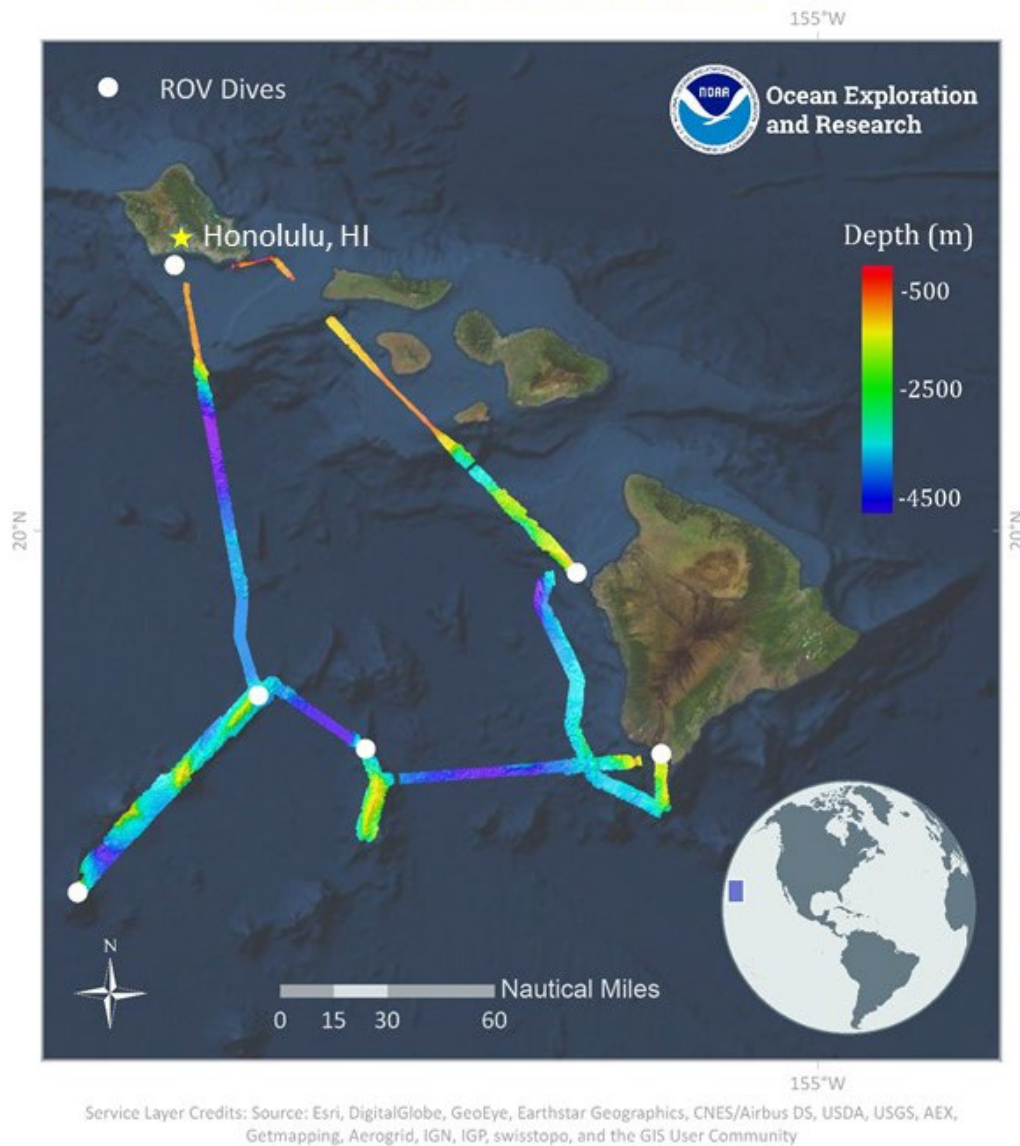


Figure 1. Cruise map showing overall EX-15-04 L3 multibeam bathymetry coverage completed during the expedition. Depth units are in meters. The yellow star indicates the location of Honolulu, HI the starting and ending port for the cruise. White dots represent completed ROV dive locations.

All of the multibeam data acquired during this expedition were collected over previously mapped areas, so no new bathymetric features were revealed. However, McCall and Ellis Seamounts lacked backscatter data coverage. Therefore, targeted multibeam backscatter surveys were conducted on these two features. Time constraints prevented complete coverage at both sites, but the main high priority data gaps were addressed. EK 60 split-beam sonar and Knudson sub-bottom sonar data were collected during mapping operations, but were not processed or analyzed.

## 5. Mapping Statistics

**Table 1. Summary statistics of ocean mapping work completed during EX-15-04 L3.**

<b>Dates of cruise</b>	<b>August 28 – September 3, 2015</b>
<b>Linear kilometers of survey with EM 302</b>	<b>1,204</b>
<b>Square kilometers mapped with EM 302</b>	<b>6,400</b>
<b>Square kilometers mapped with EM 302 within U.S. EEZ deeper than 200 meters</b>	<b>6,400</b>
<b>Number / Data Volume of EM 302 raw bathymetric / bottom backscatter multibeam files (.all)</b>	<b>109 files/ 5.93 GB</b>
<b>Number / Data Volume of EM 302 water column multibeam files</b>	<b>109 files/ 23.3 GB</b>
<b>Number / Data Volume of EK 60 water column split beam files (.raw)</b>	<b>137 files / 1.04 GB</b>
<b>Number / Data Volume of sub-bottom sonar files (.segy, .kea, .keb)</b>	<b>351 files / 1.42 GB</b>
<b>Number of XBT casts</b>	<b>17</b>
<b>Number of CTD casts (including test casts)</b>	<b>0</b>

## 6. Mapping Sonar Setup

The following sonars were operated during the cruise:

### *Kongsberg EM 302 Multibeam Sonar*

NOAA Ship *Okeanos Explorer* is equipped with a 30 kilohertz (kHz) Kongsberg EM 302 multibeam sonar capable of detecting the seafloor in up to 10,000 meters of water and conducting productive mapping operations in 8,000 meters of water. The system generates a 150° beam fan containing up to 432 soundings per ping in waters deeper than 3,300 meters. In waters shallower than 3,300 meters the system is operated in dual swath mode, and obtains up to 864 soundings per ping by generating two swaths per ping cycle. The

multibeam sonar is used to collect seafloor bathymetry, seafloor backscatter, and water column backscatter data. Backscatter represents the strength of the acoustic signal reflected from a target, such as the seafloor or bubbles in the water column. The system undergoes a patch test calibration annually and the results are reported in the annual readiness report.

#### *Simrad EK 60 Split-beam Sonar*

The ship operated an 18 kHz Simrad EK 60. This sonar is a quantitative scientific echosounder calibrated to identify the target strength of water column acoustic reflectors - typically biological scattering layers, fish, or gas bubbles – providing additional information about water column characteristics and anomalies.

#### *Knudsen 3260 Sub-bottom Profiler*

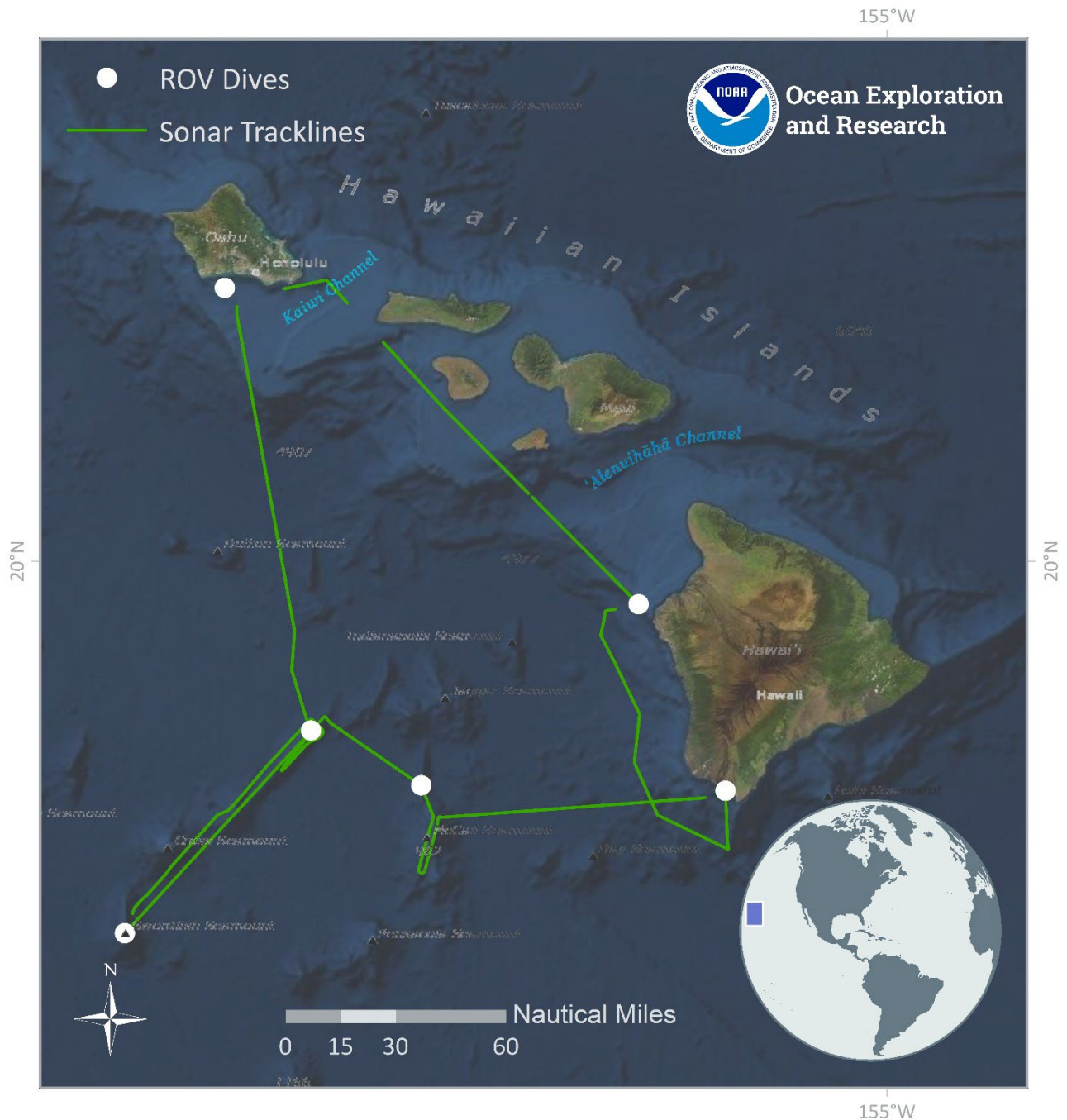
The ship is equipped with a Knudsen 3260 sub-bottom profiler that produces a frequency-modulated chirp signal with a central frequency of 3.5 kHz. This sonar is used to provide echogram images of shallow geological layers underneath the seafloor to a maximum depth of approximately 80 meters below the seafloor. The sub-bottom profiler is normally operated to provide information about sub-seafloor stratigraphy and features. The data generated by this sonar are fundamental to helping geologists interpret the shallow geology of the seafloor.

## **7. Data Acquisition Summary**

Mapping operations included EM 302 multibeam, EK 60 split-beam, and Knudsen sub-bottom profiler data collection. Throughout the cruise, multibeam data quality was monitored in real-time by acquisition watch standers. Ship speed was adjusted to maintain data quality as necessary and line spacing was planned to ensure one-quarter to one-third swath width overlap between lines. Cutoff angles in SIS were generally left wide open for maximum exploration data collection, and were adjusted on both the port and starboard side during focused survey operations to ensure the best data quality and coverage. Data were corrected for sound velocity in real-time using Reson SVP-70 probe data at the sonar head. Reson sound velocity values were constantly compared against secondarily derived sound speed values from the ship's onboard thermosalinograph flow-through system as a quality assurance measure. Expendable Bathythermographs (XBTs) were conducted every 2 to 6 hours during mapping operations to provide temperature profiles of the water column in order to calculate sound velocity profiles. These profiles are used while surveying with the multibeam sonar in order to properly account for sound speed changes and ensure the most accurate bathymetry data possible. In total there were 17 XBT casts taken as part of the mapping survey. EM 302 multibeam sonar tracklines are shown in Figure 2.

# Hohonu Moana 2015: Exploring the Deep Waters off Hawai'i

## Sonar Data Collection Tracklines and ROV Dive Map



Service Layer Credits: Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AEX, Getmapping, Aerogrid, IGN, IGP, swisstopo, and the GIS User Community  
 Sources: Esri, GEBCO, NOAA, National Geographic, DeLorme, HERE, Geonames.org, and other contributors

Figure 2. Cruise map showing ROV dive locations (white) and EM 302 multibeam, EK 60 split-beam, and Knudsen sub-bottom profiler sonar acquisition tracklines (green) completed during EX-15-04 L3.



Simrad EK 60 split-beam water column sonar data and Knudsen 3260 sub-bottom profiler data were collected continuously during the cruise while mapping, but not during ROV dive operations. Data were monitored in real time for quality but were not post-processed.

## 8. Multibeam Sonar Data Quality Assessment and Data Processing

Figure 3 shows the multibeam data processing workflow for this cruise. EM 302 Built-in Self Tests (BISTs) were run throughout the cruise to monitor multibeam sonar system status and are available as ancillary files in the sonar data archives. Raw multibeam bathymetry data files were acquired by SIS, and were imported into CARIS software. In CARIS, attitude and navigation data stored in each file were checked, and erroneous soundings were manually removed using CARIS Swath Editor and Subset Editor. With the vast majority of surveying completed in deep water, depth measurements were not adjusted for tides, as they are an essentially insignificant percent of the overall water depth. Data cleaning projects were in UTM zone projections for the operations area. Final data products were exported and archived as field geographic WGS84 coordinate reference frame (i.e., unprojected).

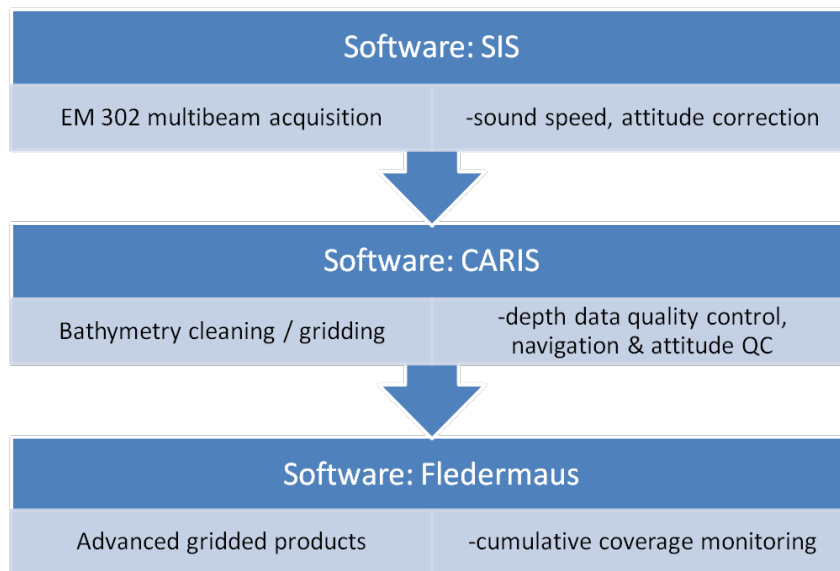


Figure 3. Shipboard multibeam data processing workflow.

### Crosslines

Comparing depth values from orthogonal survey lines is a standard hydrographic quality control measure to evaluate the consistency of the multibeam sonar data collected during a cruise. A crossline was run on August 30, 2015 as shown in Figure 4. Crossline analysis was completed using the Crosscheck Tool in QPS Qimera software and confirmed the data meet the requirements for an International Hydrographic Order 1 survey. The results are shown below.

Crossline file:

0027\_20150830\_102731\_EX1504L3\_MB.all

Mainscheme line file:

0036\_20150831\_044349\_EX1504L3\_MB.all

Depths listed ("Z") are in meters.

<u>Statistic</u>	<u>Value</u>
Number of points of comparison	84720
Grid Cell Size	50
Difference Mean	-0.516
Difference Median	-0.516
Difference Std. Dev	11.049
Difference Range	[-189.4, 115.5]
Mean + 2*Stddev	22.615
Median + 2*Stddev	22.615
Data Mean	-3496.80
Reference Mean	-3496.28
Data Z-Range	[-4134.60, -2655.96]
Reference Z-Range	[-4115.75, -2671.74]
Order 1 Error Limit	45.4544
Order 1 # Rejected	740
Order 1 P-Statistic	0.00873466
<b>Order 1 Survey</b>	<b>ACCEPTED</b>



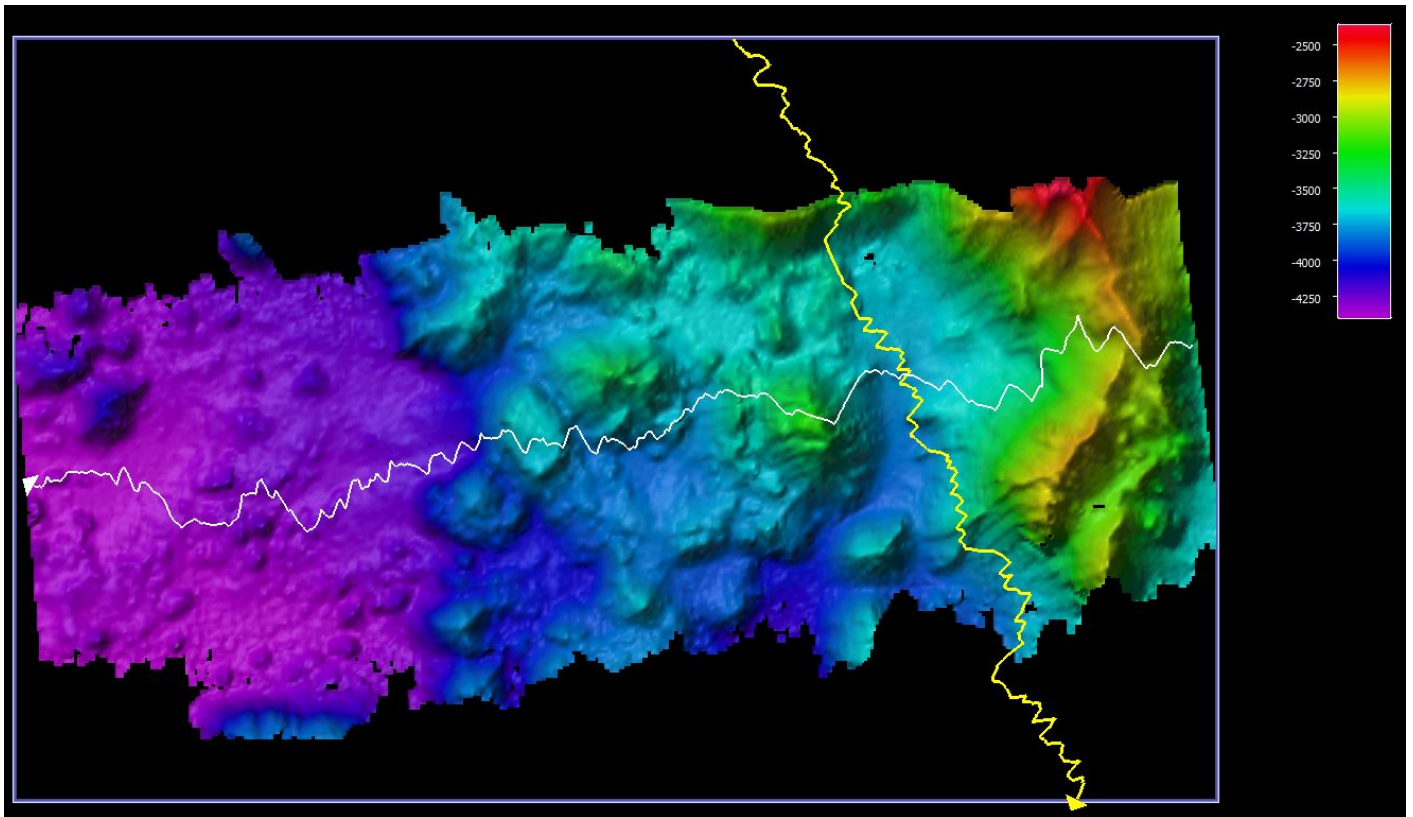


Figure 4. EX-15-04 L3 crossline (shown in yellow) used for comparison against the bathymetric grid generated via orthogonal multibeam survey lines.

## 9. Data Archival Procedures

All mapping data collected by the NOAA Ship *Okeanos Explorer* are archived and publicly available within 90 days of the end of each cruise via the National Centers for Environmental Information (NCEI) online archives. The complete data management plan (which describes the raw and processed data formats produced for this cruise) is available as an appendix in the EX-15-04 L3 project instructions available in the NOAA Central Library at <http://doi.org/10.7289/V5DB7ZVQ>. Ancillary and supporting files are archived with the sonar datasets. These include:

*EM 302 Multibeam bathymetry and bottom backscatter dataset:*

- Mapping watch stander log
- Multibeam acquisition and processing log

*Simrad EK 60 split-beam water column dataset:*

- Mapping watch stander log

*Knudsen 3260 Sub-bottom Profiler dataset:*

- Mapping watch stander log

*EM 302 Multibeam water column dataset:*

- Mapping watch stander log
- Multibeam acquisition and processing log

All sonar data are permanently discoverable at <https://www.ngdc.noaa.gov/>

EM 302 and EK 60 water column data, supporting data, and informational logs are available in the NCEI Water Column Sonar Archives:

- EM 302 water column data can be found here: <http://doi.org/10.7289/V5Z0365N>
- EK 60 water column data can be found here: <http://doi.org/10.7289/V52R3PPP>

Sub-bottom profiler data, supporting data, and informational logs are available in the NCEI Data Archives accessible at <https://www.ngdc.noaa.gov/>. For assistance in accessing SBP data, send an inquiry to [ncei.info@noaa.gov](mailto:ncei.info@noaa.gov) requesting access to EX-15-04 L3 Knudsen 3260 sub-bottom raw and processed data.

EM 302 bathymetry data, supporting informational logs, and ancillary files are available in the NCEI Data Archives accessible at <https://maps.ngdc.noaa.gov/viewers/bathymetry/> (last accessed 3/3/2020).



## 10. Cruise Calendar

*All times listed are local ship time, which was -10 hours from UTC*

### August/September 2015

Sun	Mon	Tues	Wed	Thur	Fri	Sat
26	27	28 Start of expedition. ROV dive 1 attempt.	29 ROV dive 2 near Kona, Hawaii and transit mapping.	30 ROV dive 3 near South Point, Hawaii and transit mapping.	31 ROV dive 4 at McCall Seamount and transit mapping.	1 Sept ROV dive 5 at Swordfish Seamount and transit mapping.
2 ROV dive 6 at Ellis Seamount and transit mapping.	3 ROV dive 7 and transit mapping into port in Pearl Harbor.	4	5	6	7	8

## 11. Daily Cruise Log Entries

*Generated from the daily expedition situation reports. All times listed are in local ship time which was Hawaii Standard Time (HST) (-10 hours from Coordinated Universal Time (UTC)).*

*August 28, 2015*

NOAA Ship *Okeanos Explorer* departed Pearl Harbor, O'ahu, about 0930 this morning to commence Leg 3 of the Hohonu Moana Expedition. All sonars were turned on for the short transit to the Dive 1 location, and seas were calm. The multibeam passed all BIST tests on the first attempt and ran normally.

The first dive was planned for this afternoon at Makapuu, located about six nautical miles off the easternmost point of O'ahu. After deploying the ROV today, a problem was discovered with the hanging block and the vehicles were quickly recovered. The team spent the afternoon troubleshooting the block, and the dive was cancelled. Mapping transit operations commenced in the evening and the ship transited to Keahole off the west coast of the Big Island for Dive 2 of the expedition.

The night transit to Dive 2 had to be done at roughly 10 knots, and mapping data quality was good considering the vessel speed. As a precaution, we turned off all sonars for approximately two hours during the night time transit over Penguin Bank, which is in the Hawaiian Islands Humpback Whale National Marine Sanctuary. The area is relatively shallow and very well mapped already.



*August 29, 2015*

Dive 2 was conducted today off the Kona Coast of the Big Island of Hawai'i at the Keahole precious coral bed. During the dive, the team recovered an acoustic current meter and three flow meters that were deployed in 2012 to collect data on the environmental conditions surrounding these deep-sea coral communities. We also investigated nearby previously marked coral colonies and conducted close-up imaging for comparison to photographs taken over three years ago. Two biological specimens (a black and bamboo coral) were collected and 10 scientists participated remotely.

Overnight mapping operations followed a transit line south 12 miles offshore of the Big Island. All sonars operated normally. This area is already well mapped, so there were no obvious holidays to fill in the synthesis bathymetry dataset for the region. Daily multibeam products are being made and posted to the FTP.

*August 30, 2015*

Dive 3 of the expedition was conducted today along a 450 m contour at the southern end of the Kona Coast of the Big Island of Hawai'i with the objective of surveying a lava flow of a known age (1868) to see what coral community had grown in the years since the flow had formed.

*August 31, 2015*

Overnight mapping operations moved west from Dive 3 near the Big Island to the Dive 4 site on McCall Seamount. The transit to McCall was conducted at full ship speed since the area is already well mapped and the priority was on gathering high quality backscatter data lines over McCall Seamount since there is no backscatter data available for that area. The multibeam was kept in Deep mode throughout the backscatter survey on McCall to ensure consistency. A backscatter mosaic was completed for McCall and will be part of the final products for the cruise as an addition to the regional backscatter synthesis. All sonars are running well and data quality is high. All BIST tests passed without issue on the EM 302. The TRU is being kept on during dives.

Dive 04 was conducted today on McCall Seamount and was the first dive this cruise in the group of topographic features referred to as the Geologists Seamounts. The dive surveyed the crest of a sharp ridge that extended north of the seamount at a depth of 2,700 m.

*September 1, 2015*

Overnight mapping operations moved northwest from Dive 4 on McCall Seamount to the Dive 5 site on Swordfish Seamount. Backscatter surveying over Ellis Seamount (where Dive 6 will be conducted) was completed during the transit to Swordfish.

Dive 5 of this expedition was the first dive ever conducted on Swordfish Seamount, located in the Geologists Seamounts group. The dive plan was to survey the upper crest of the ridge shaped summit at a depth of approximately 1000m to search for corals and sponges. Three rocks (Basalt and carbonate), two corals and a sponge were collected during today's dive. 14 scientists participated remotely.



Following the dive on Swordfish Seamount, mapping operations were conducted during transit to Dive 6, Ellis Seamount. Complementing the previous night's work, the focus of multibeam mapping was on gathering data for a high quality backscatter mosaic of Ellis Seamount. The multibeam was kept in Deep mode for most of the survey lines in order to keep backscatter data comparable along the length of the seamount (i.e., minimizing changes to source power, pulse lengths, gain, etc., of the multibeam while surveying).

#### *September 2, 2015*

Dive 6 was the first dive ever conducted on Ellis Seamount located in the Geologists Seamounts group. The objective of this dive was to survey a rift zone ridge coming off the northern end of the seamount for corals and sponges, to gather more information on whether high-density communities can be found on ridge topography. From beginning to end, the dive observed high densities of coral colonies.

Following completion of the dive on Ellis Seamount, underway mapping was conducted during the overnight transit to Pearl Harbor to pick up VIPs early on Thursday morning. Sonars were secured and no data were collected during the transit to and from the S-19 submarine for dive 07. The mapping team spent the day wrapping up the cruise.

#### *September 3, 2015*

EX arrived at Pearl Harbor at approximately 0630 this morning and several VIPs were brought onboard via small boat. Underwater Cultural Heritage (UCH) protocols were implemented for today's dive.

Sonars were secured and no data were collected during the transit to and from the S-19 submarine for dive 7. Dive 7 visited the hull of the World War I submarine S-19. A complete survey of the of the full deck area of the S-19 hull was conducted with attention to the deep coral community growing on it, looking for any evidence of recent arrival of the parasitic gold coral. A previously deployed flow meter instrument was recovered, and the team practiced deployment and recovery of a mock-up tilt meter instrument to inform future operations.

Following completion of today's dive, the ship made its way back into port in Pearl Harbor and was secured alongside in the late afternoon. Onboard personnel spent the day processing data and preparing end of cruise documentation.



## 12. References

The 2015 NOAA Ship *Okeanos Explorer* Survey Readiness Report can be obtained in the NOAA Central Library or by contacting the NOAA OER mapping team at [oar.oer.exmappingteam@noaa.gov](mailto:oar.oer.exmappingteam@noaa.gov).

The EX-15-04 L3 Project Instructions can be obtained from the NOAA Central Library at <http://doi.org/10.7289/V5DB7ZVQ>. The EX-15-04 L3 Data Management Plan is an appendix of the project instructions.

The following data were used as background data throughout the expedition:

- Tozer, B. , D. T. Sandwell, W. H. F. Smith, C. Olson, J. R. Beale, and P. Wessel, Global bathymetry and topography at 15 arc seconds: SRTM15+, Accepted Earth and Space Science, August 3, 2019. <https://doi.org/10.1029/2019EA000658>
- NOAA Nautical Charts
- Various datasets downloaded from the NCEI archives via NOAA AutoChart.

A full description of Remotely Operated Vehicle (ROV) operations and sample collections completed during the cruise is available in a separate Expedition Report available in the NOAA Central Library with the title “*Cruise Report: EX-15-04 L3, Hohonu Moana 2015: Exploring the Deep Waters off Hawai’i (ROV & Mapping).*”

